ATMS Full Radiance Calibration (FRC) Implementation and Validation

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August 26, 2015

Outline

- Introduction of ATMS FRC equations
- Implementation of FRC in ADL
- Test of FRC in ADL
- Validation of FRC TDR
- Summary and future work

ATMS Radiance Calibration Equations

The scene radiance is derived as the sum of linear part and nonlinear part:

$$R_b = R_{b,I} + Q_b$$

where the linear term is

$$R_{b,I} = R_w + G_b^{-1}(C_s - C_w)$$

$$G_b = \frac{C_w - C_c}{R_w - R_c}$$

And nonlinear term is

$$Q_b = \mu G_b^{-2}(C_s - C_w)(C_s - C_c) = \mu(R_w - R_c)^2 x(x-1)$$

$$x = \frac{C_s - C_c}{C_w - C_c}$$

Using Taylor expansion for f(x) = x(x-1) at x0=0.5 , Nonlinearity term can be expressed as function of the maximum nonlinearity:

$$Q_b = Q^{\max}[4 \cdot (x - 0.5)^2 - 1]$$

$$Q^{\max} = \frac{1}{4} \cdot \mu \cdot (R_w - R_c)^2$$

"μ" is a function of instrument temperature and can be determined from TVAC test

$$\mu = aT^2 + bT + c$$

Implementation of Radiance Calibration in ADL

- The spectral radiance of cold end is determined at side lobe corrected cosmic background temperature of 2.73K
- The spectral radiance of warm target radiance is calculated at bias corrected warm load temperature
- Compute calibration gain in radiance, by which the linear part of scene radiance can be derived
- Calculate “mu” parameter from receiver temperature (in ^{o}C), from which the maximum nonlinearity Q^{max} can be derived
- Derive the nonlinear part of scene radiance from Q^{max}, find the calibrated scene radiance from sum of linear and nonlinear part
- Transfer spectral scene radiance back to brightness temperature by inverse Planck function

ADL Test Environment

Package:

ADL 4.2 with MX 8.8
Version 1: Nonlinearity coefficients derived from temperature
Version 2: Nonlinearity coefficients derived from radiance

Data Ingested:

S-NPP RDR data on April 7, 2015

Output Data:

- TDR/SDR/GEO using full radiance calibration (FRC) algorithm

Validation Provided:

FRC TDR – IDPS TDR
FRC TDR-RTM bias (with ECMWF forecasts as model inputs) by channels

- Global mean
- Global distribution
- Angler dependence

FRC TDR-RTM bias (with GPS-RO as model inputs) for channel 6 to 13

- Global mean

Validation by RTM Simulation- Using ECMWF Forecast Data

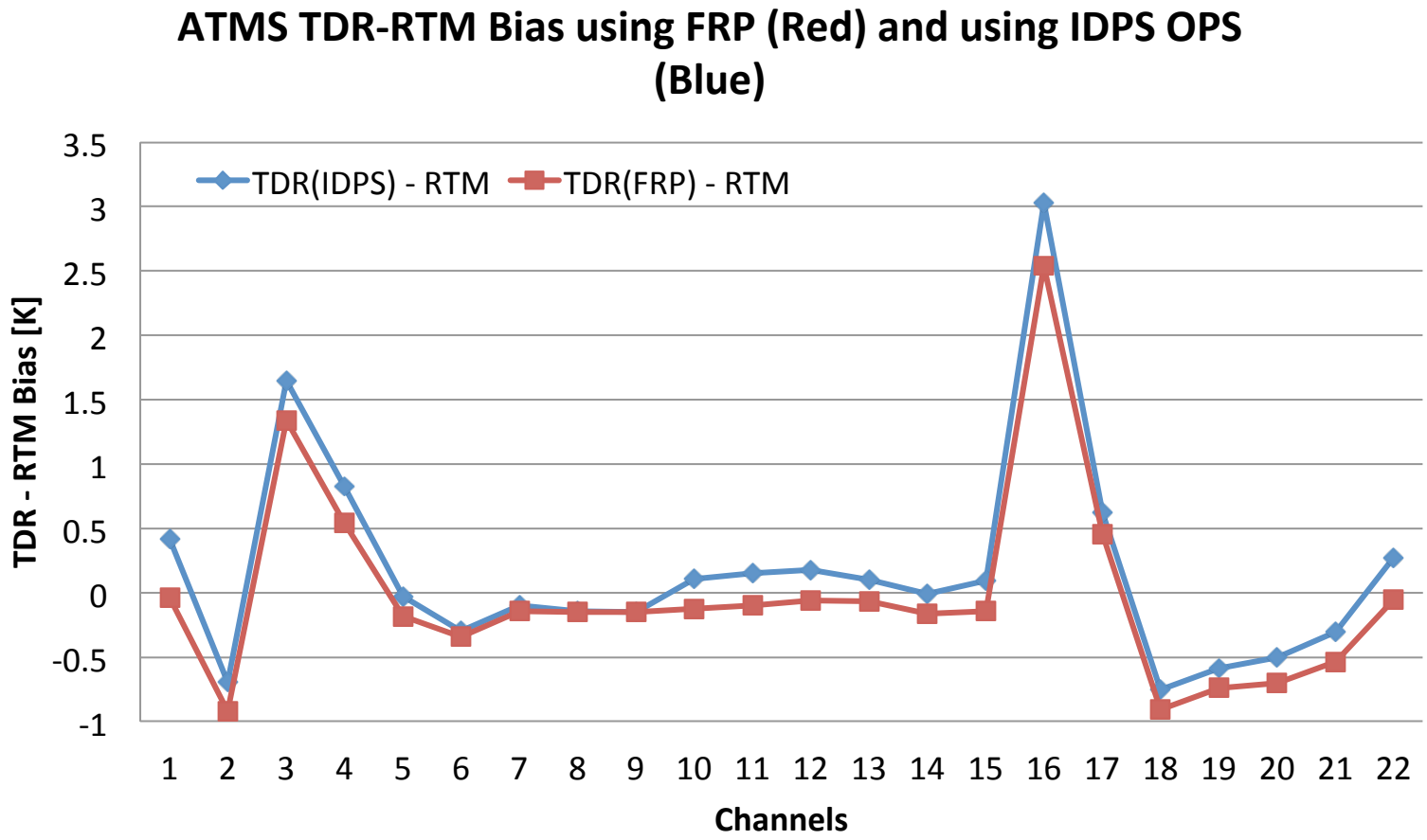
- One day ATMS observations are obtained to compare with CRTM simulations using ECMWF analysis forecast data

- Channels 1-6, and 16-22 are over ocean between 55^0S to 55^0N and cloud liquid water path is less than 0.08 kg/m^2 to remove water cloud

- Only FOVs 43~58 were used to get global mean

Global Mean TDR-RTM Bias

- Calibrated scene temperature from ADL-Full radiance are consistently lower than IDPS at all ATMS channels
- Major cause of the difference is due to the incorrect application of nonlinearity correction in IDPS

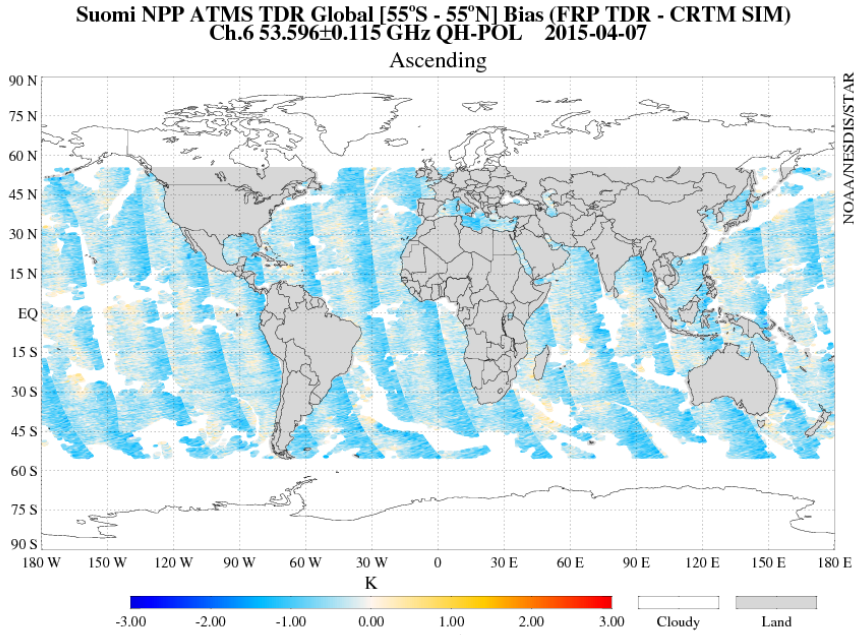


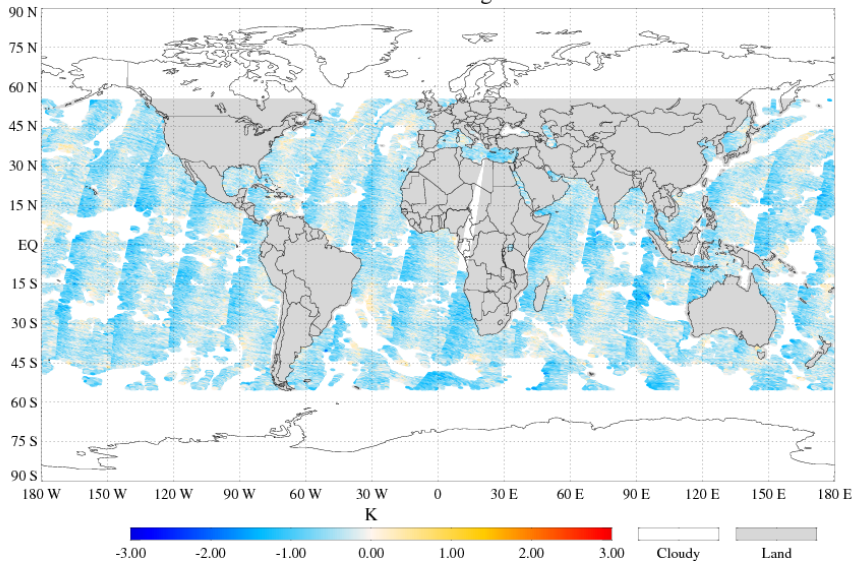
Global Mean Bias Table

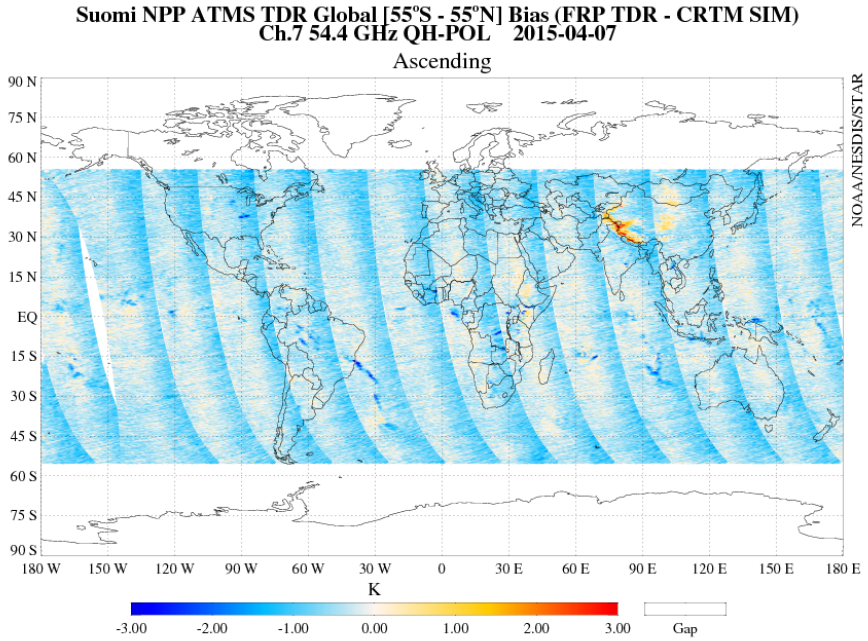
FRC: TDR from ADL with Full Radiance Calibration **OPS:** TDR from IDPS
RTM: RTM simulation

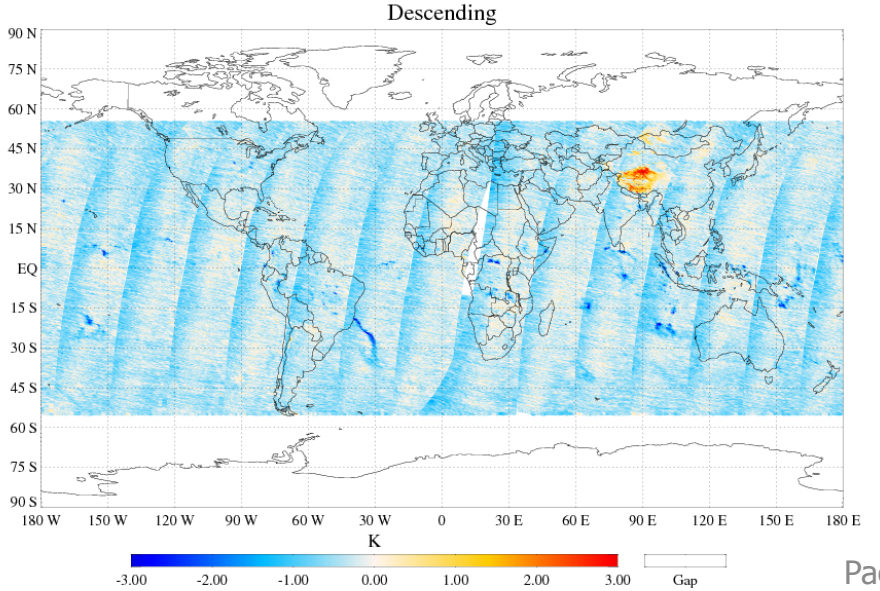
Ch.	FRC-OPS	FRC-RTM	Ch.	FRC-OPS	FRC-RTM
1	-0.448	-0.039	**12**	-0.425	-0.057
2	-0.279	-0.923	**13**	-0.312	-0.069
3	-0.330	1.341	**14**	-0.243	-0.165
4	-0.352	0.546	**15**	-0.302	-0.14
5	-0.332	-0.184	**16**	-0.539	2.543
6	-0.269	-0.339	**17**	-0.366	0.452
7	-0.274	-0.142	**18**	-0.330	-0.905
8	-0.462	-0.151	**19**	-0.357	-0.743
9	-0.166	-0.149	**20**	-0.393	-0.702
10	-0.464	-0.123	**21**	-0.391	-0.532
11	-0.495	-0.099	**22**	-0.486	-0.052

FRC TDR – RTM Global Distribution









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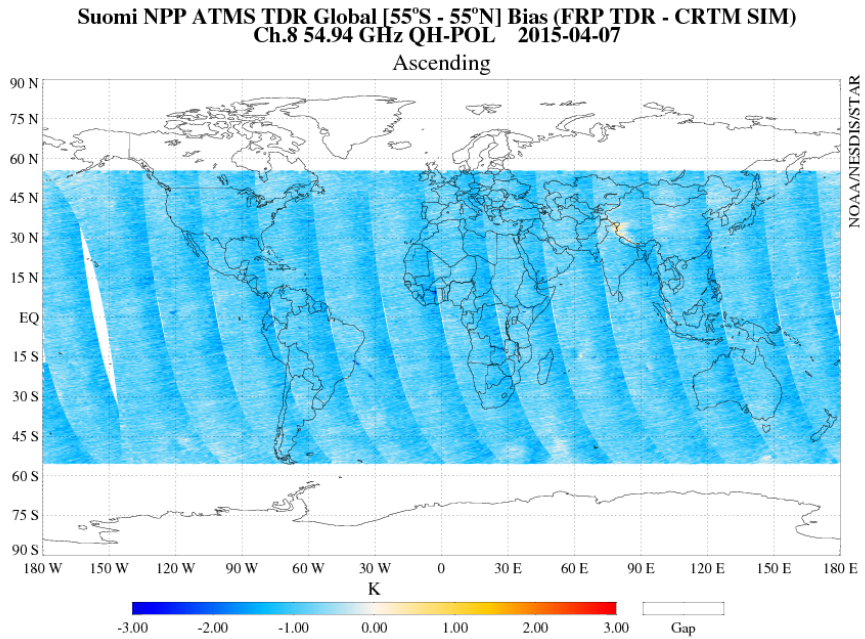

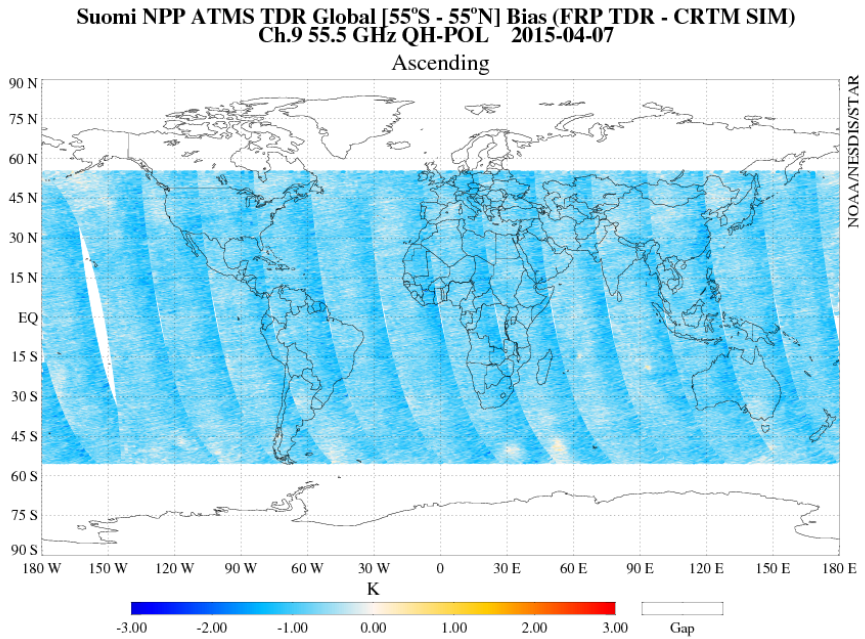

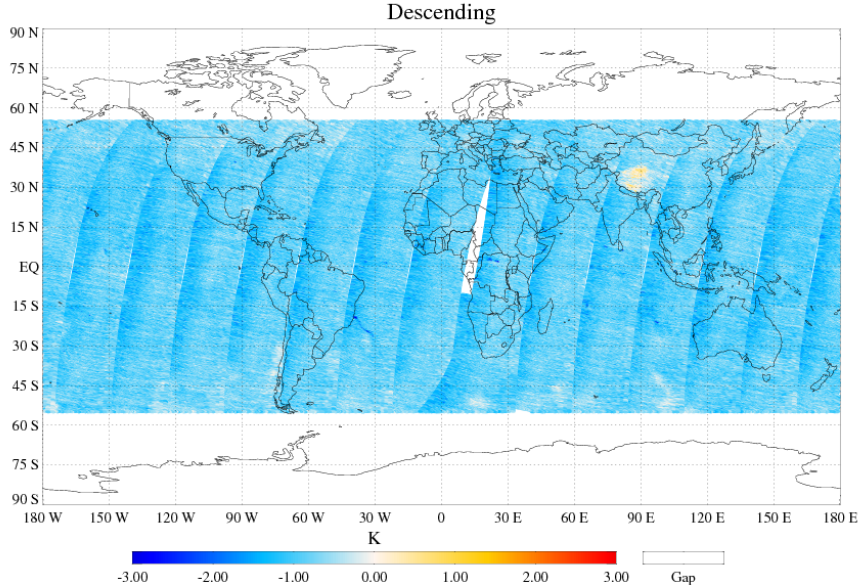

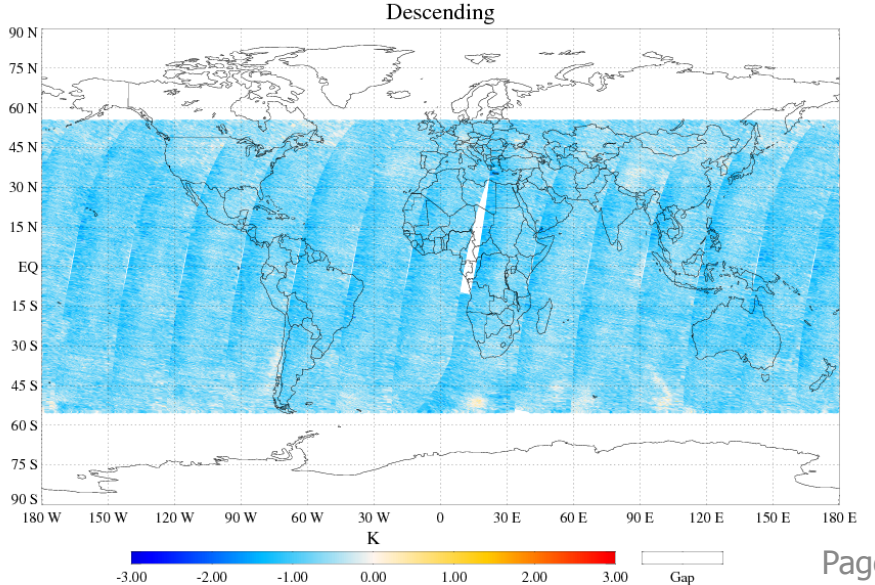

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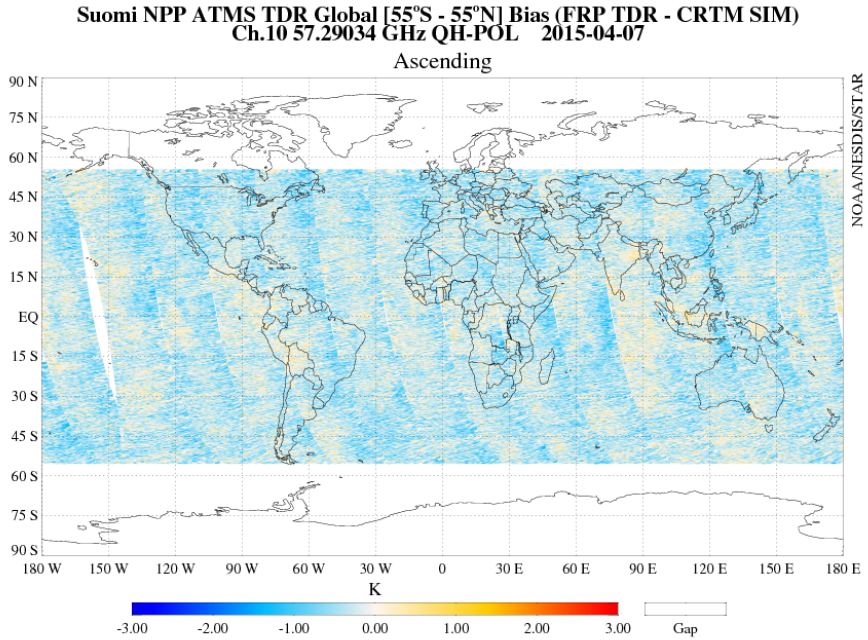

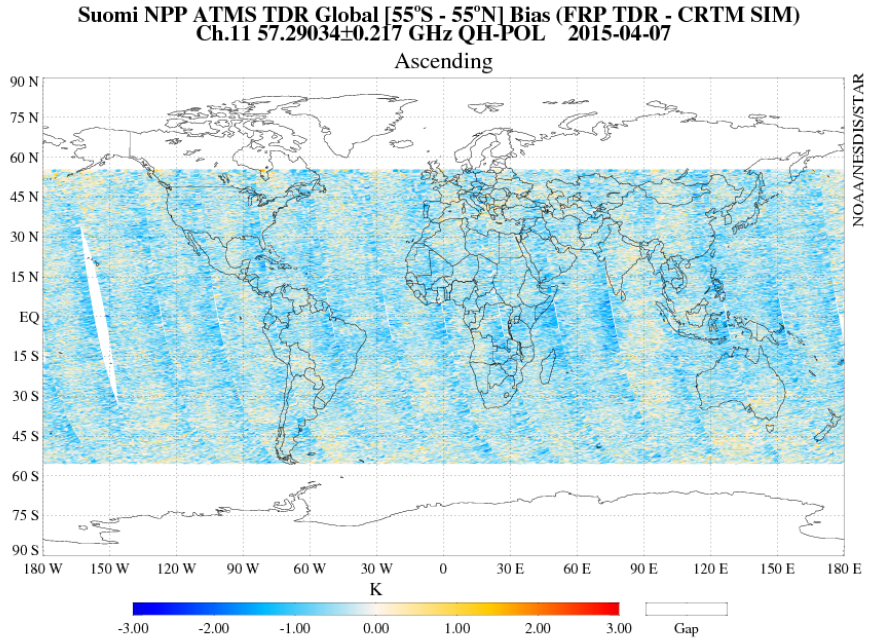

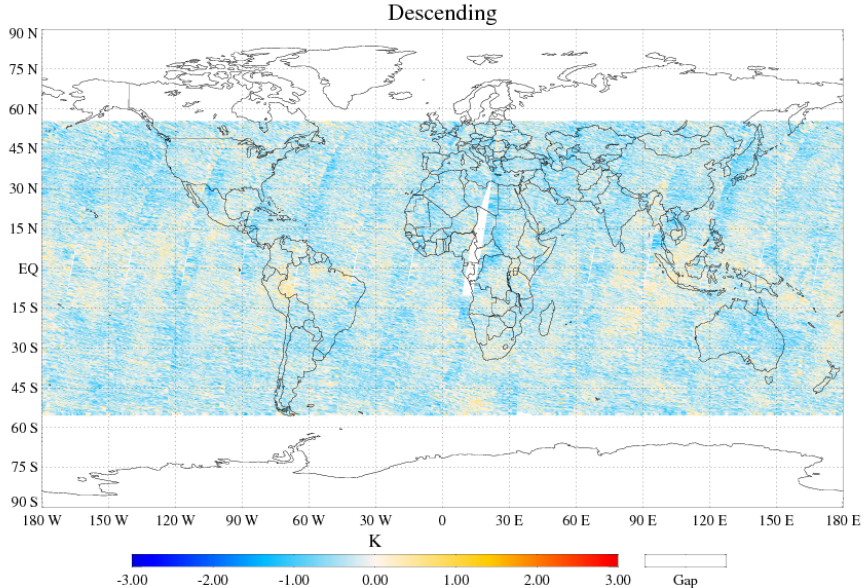

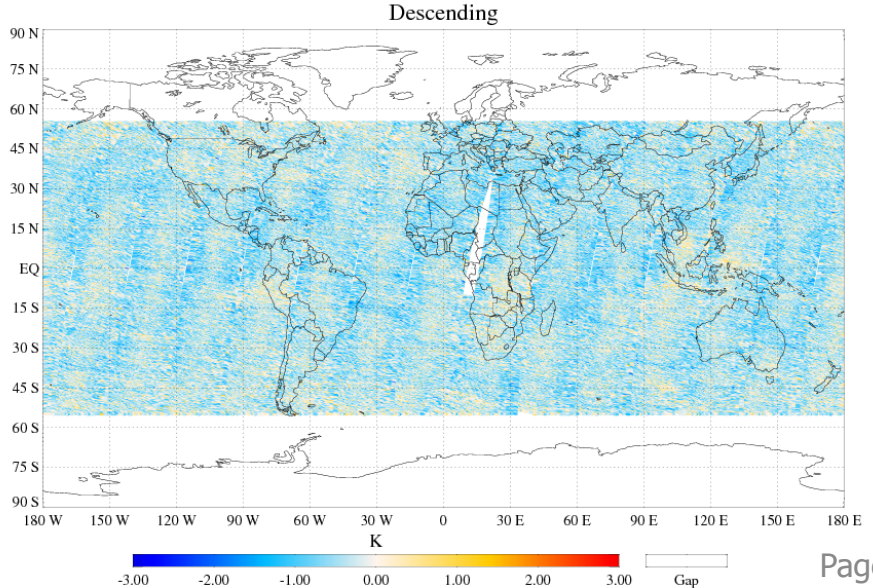

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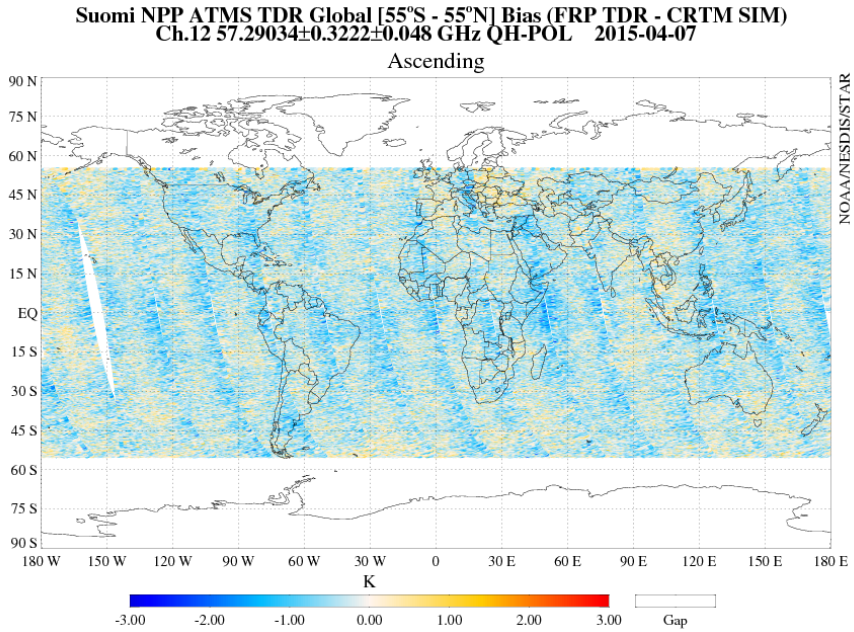

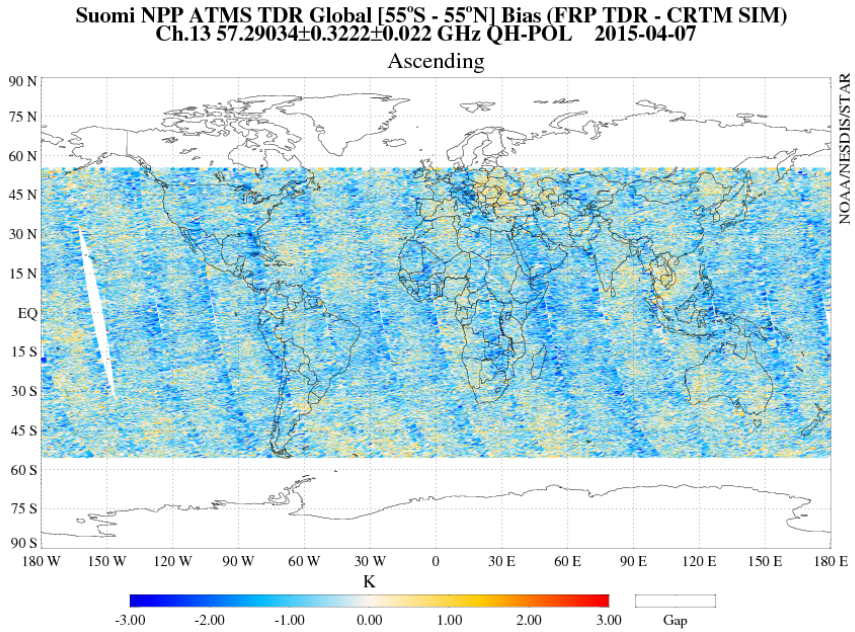

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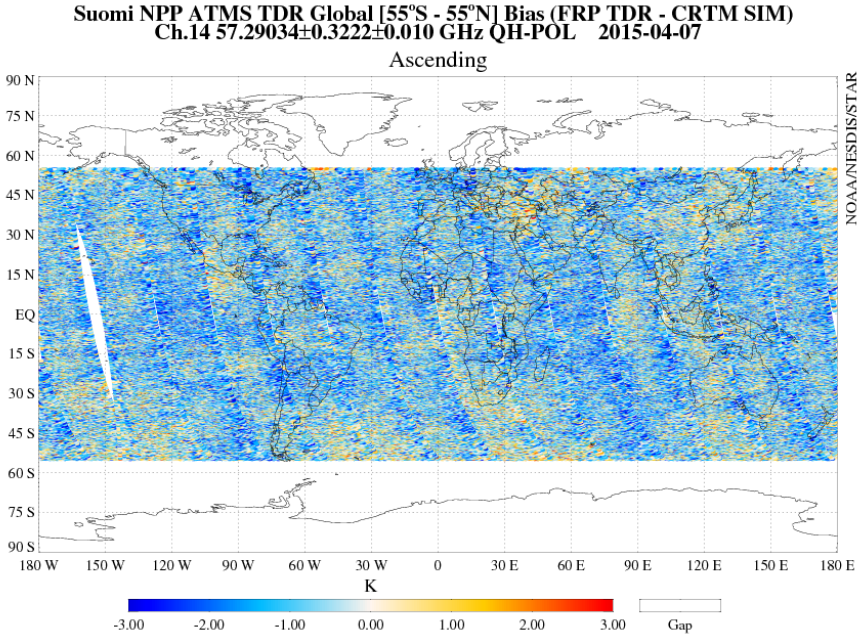
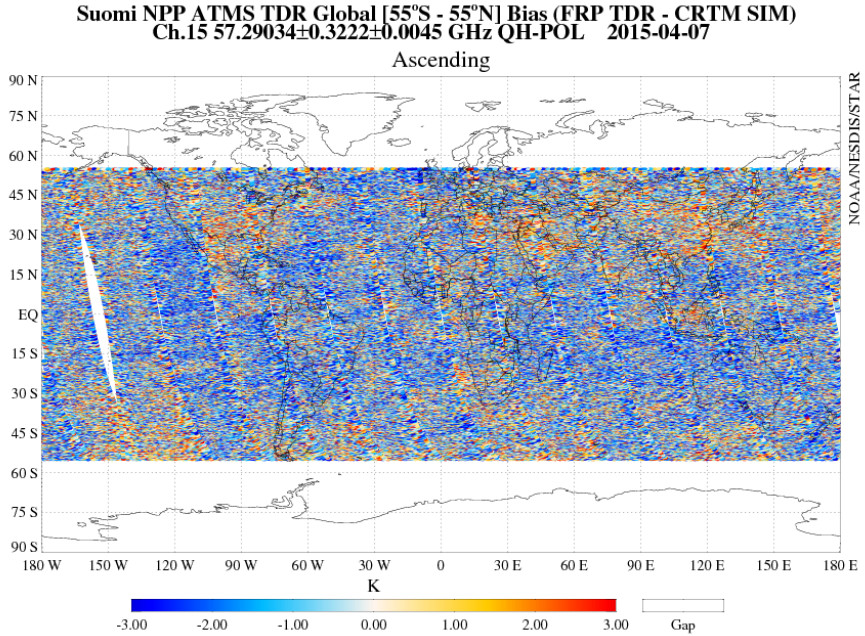
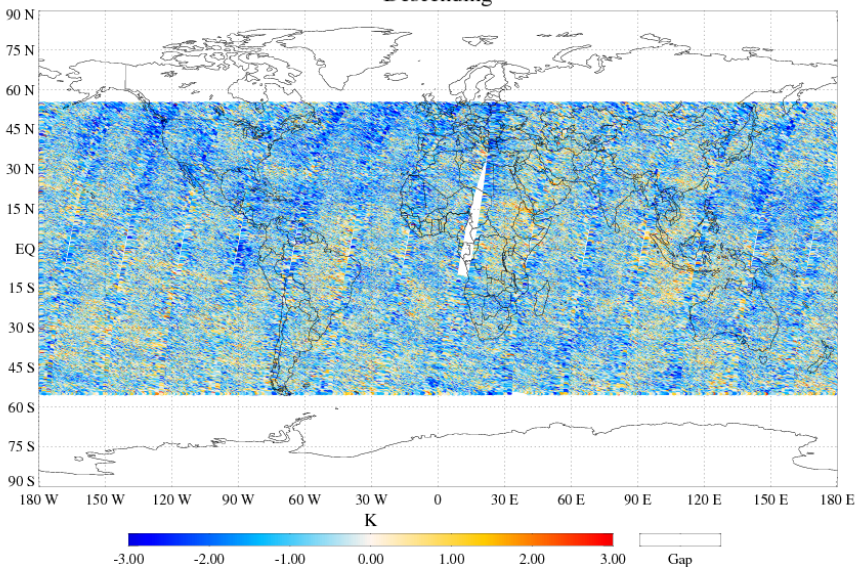
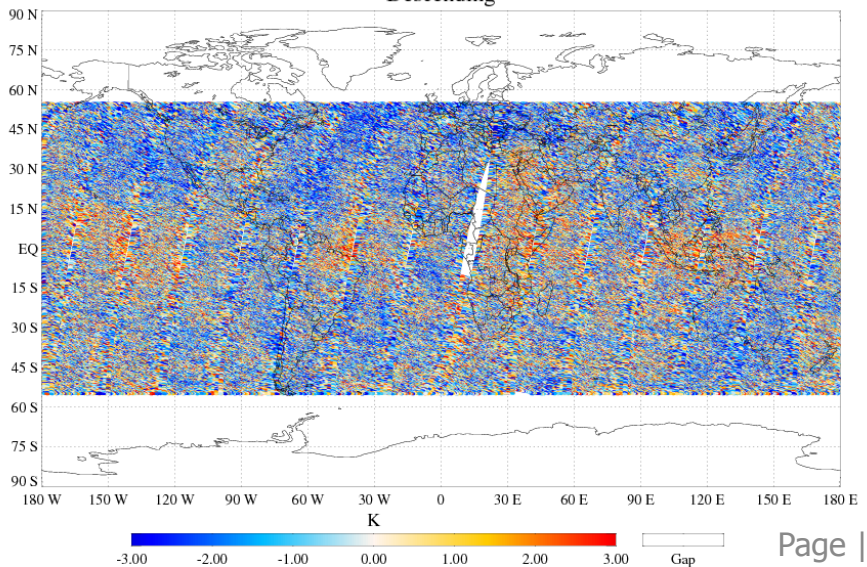


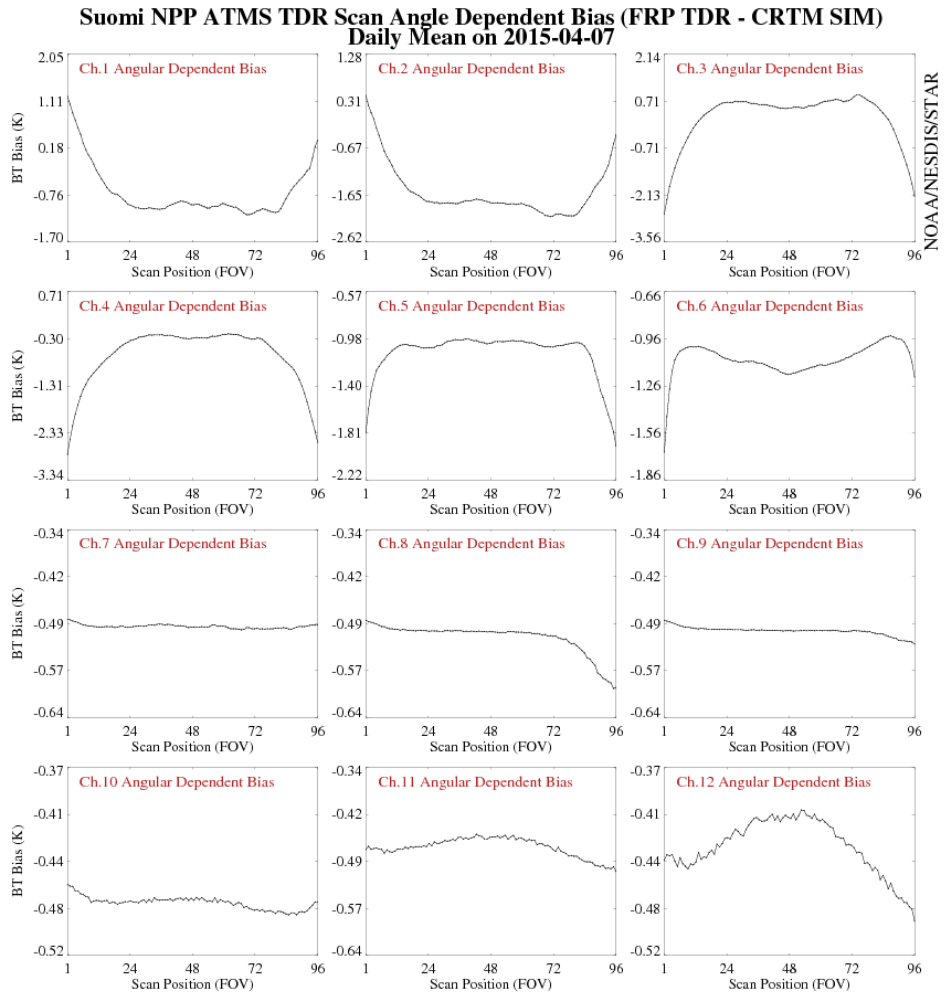




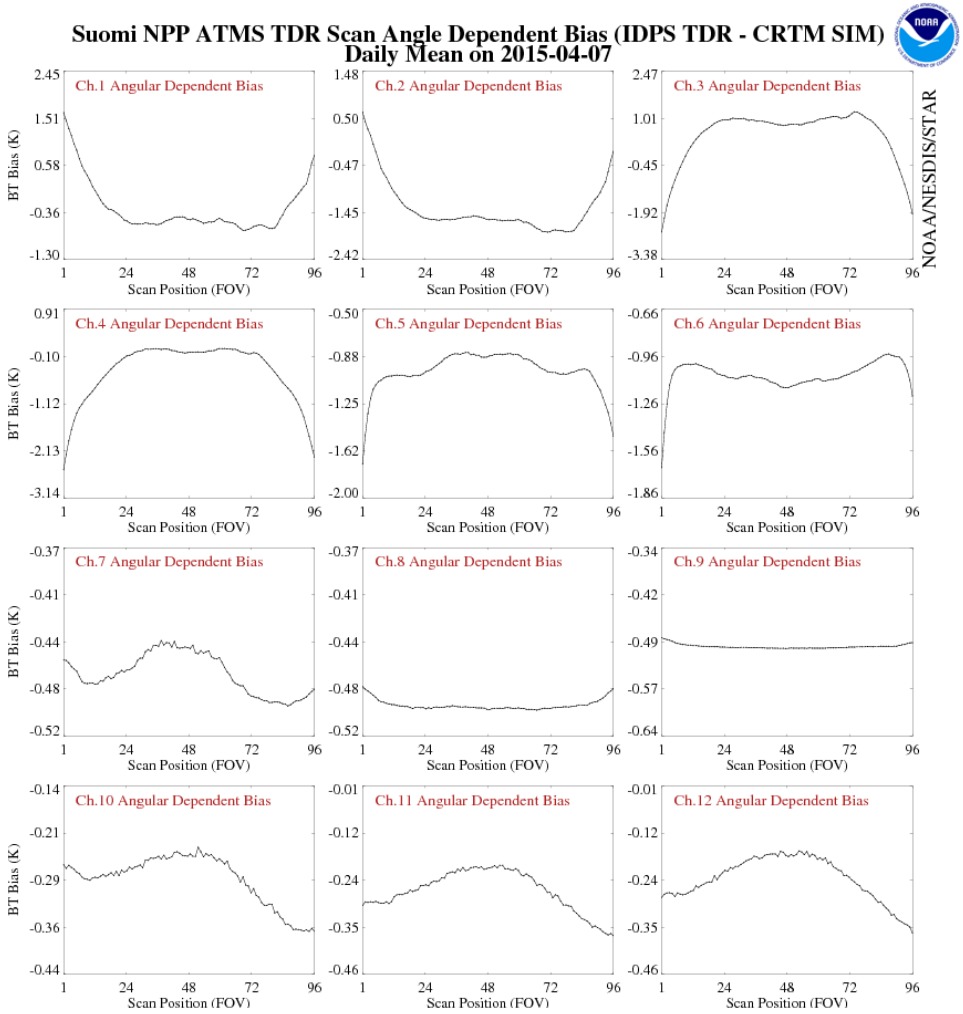


FRC TDR – RTM Angular Dependent Bias

FRC TDR - RTM



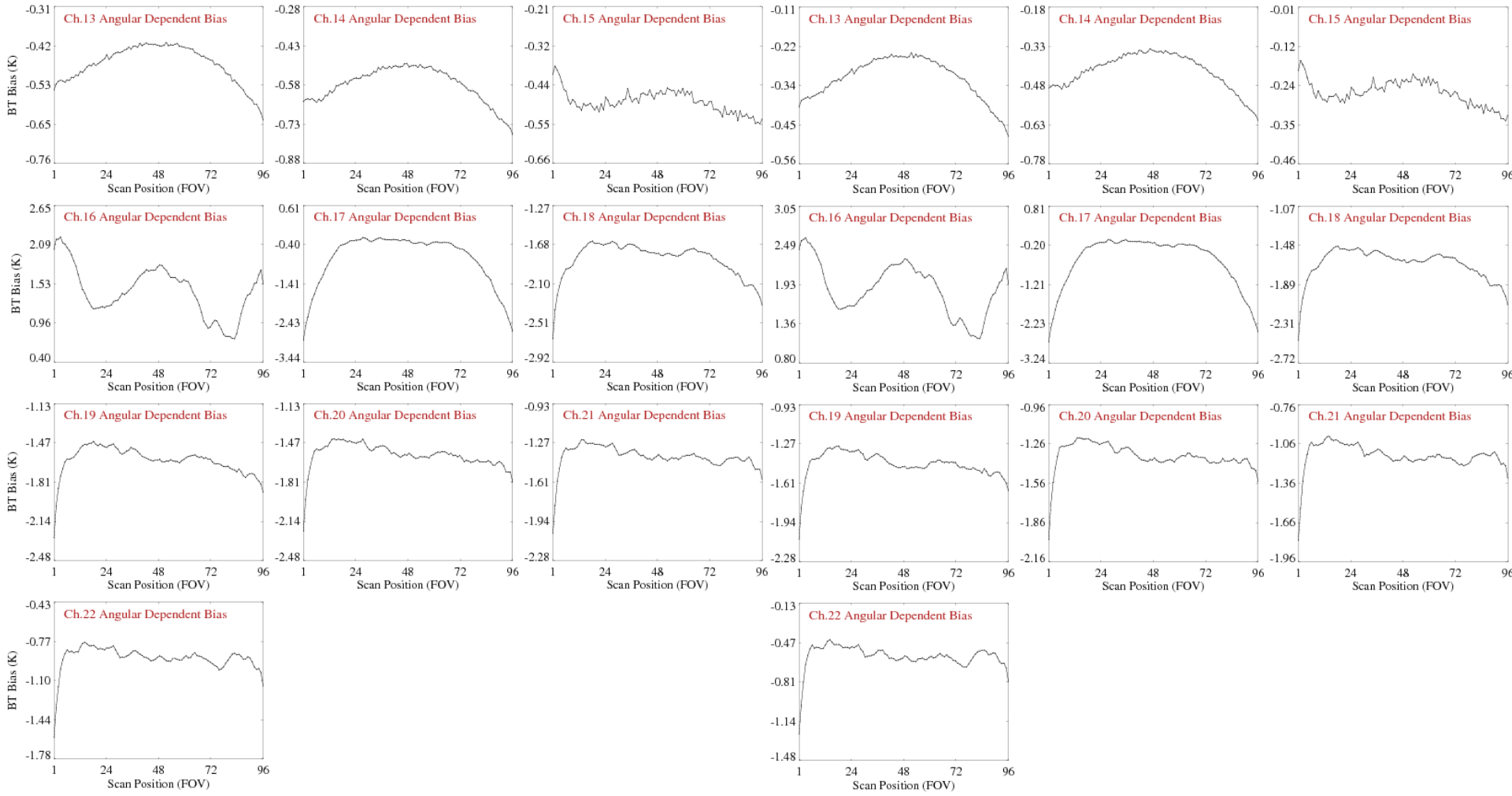
OPS TDR - RTM



FRC TDR – RTM Angular Dependent Bias

FRC TDR - RTM

OPS TDR - RTM



Validation by RTM Simulation- Using GPS RO Data

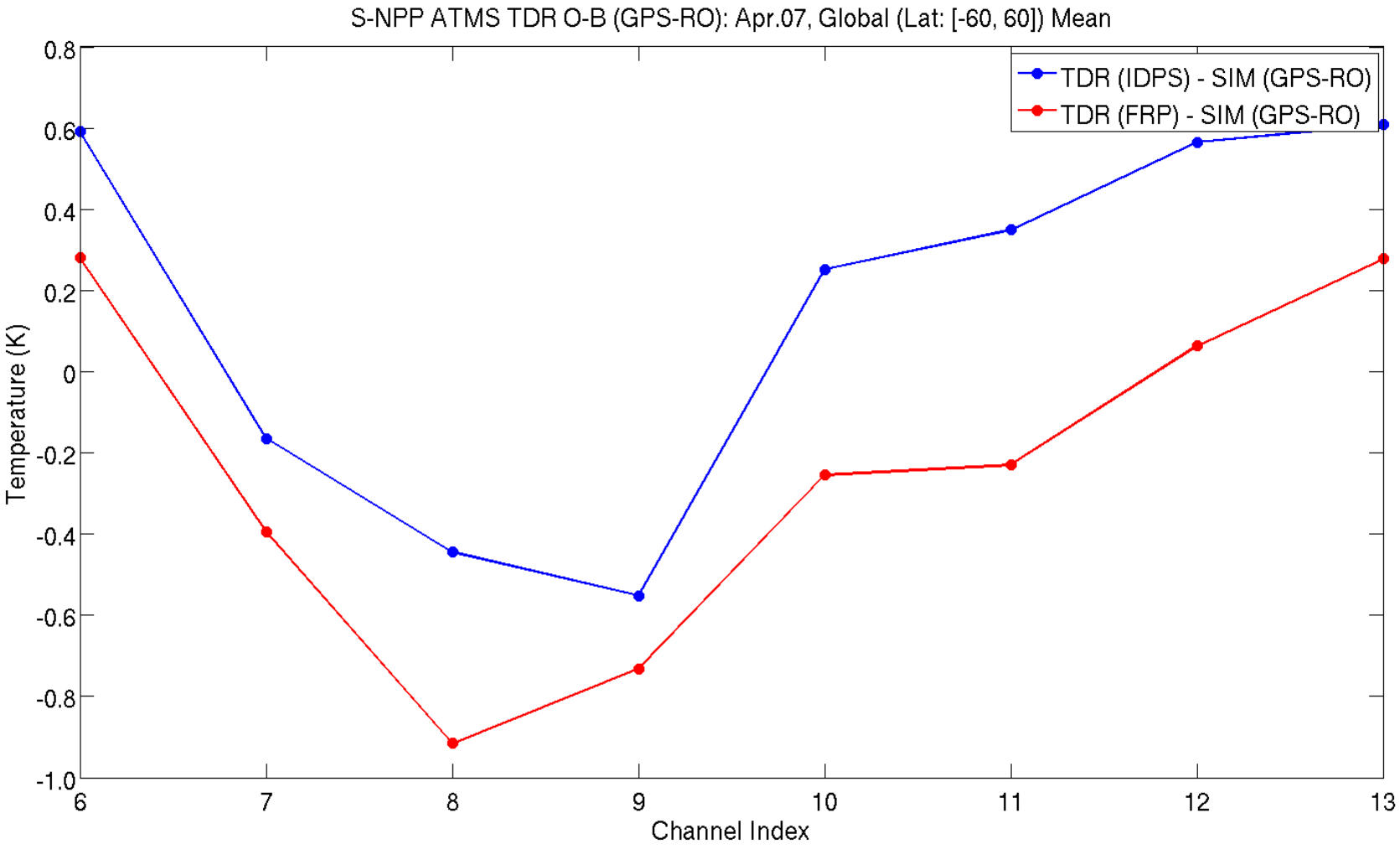
COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate): real-time level 2 retrievals; ~1500 ROs daily

Collocation of ATMS and GPS Data:

- Temporal difference < ±3 hrs
- Spatial distance ≤ 50 km
- Use GPS RO geolocation at the altitude of maximum WF for spatial collocation

Global Mean TDR-RTM Bias

- Bias characteristic is consistent with those from ECMWF simulations
- Calibrated brightness temperature from FRP is lower than IDPS



Summary and Future Work

- Full radiance calibration processing of ATMS has been implemented in ADL software
- There is no interface change made to old ADL version, only some new parameters were added to PCT
- The output TDR products from ADL-Full Radiance are in brightness temperature
- Nonlinearity correction is based on “mu” parameter, which was derived in radiance space from TVAC datasets
- Validation results shows that the overall bias characteristic of TDRs from ADL-FRC is get improved compare with TDRs from IDPS
- Suggest to make ATMS full radiance calibration available in IDPS based on current ADL-Full radiance version
- Future work is to test and implement reflector emission correction algorithm in ADL-FRC for J-1 ATMS TDRs calibration